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Solutions for Drainage and Flood Control Problems

Calco Automatic Drainage Gates

What Users Say:

REQUIRE NO ATTENTION

The Calco Automatic Drainage Gates have proven satisfactory in every way. We are particularly pleased with the simplicity and economy of installation and find that they require no attention after installation, thus eliminating maintenance expense.

This Commission has in operation two 42-inch and one 48-inch Calco Gates and two 36-inch diameter have been installed by the Seaboard By-Product Coke Company upon the recommendation of the Commission. All of these gates are functioning with the highest degree of efficiency and are satisfactorily meeting all requirements.

HUDSON CO. MOSQUITO EXTERM. COMM.,
Jersey City, N. J.

KEEP OUT FLOOD WATERS

We purchased in 1924 twenty-five Calco Automatic Drainage Gates from you, 12 to 24 inches in size. We put these in to take care of the drainage here from one of our mill yards and at the same time to keep out flood waters from a large creek that runs beside this property. These gates work perfectly and have given absolute satisfaction.

CEDARTOWN COTTON & EXPORT CO.,
Cedartown, Ga.

MAINTAIN CONSTANT WATER LEVEL

The Calco Automatic Drainage Gates which we bought are performing highly satisfactorily. These gates were used in the City of Reno's illuminated dam which performs a double duty: covers up unsightly rocks and reefs and makes a place suitable for light boating. Your drainage gates keep the water at a constant level, making the dam very spectacular when illuminated at night.

NEVADA LAND COMPANY,
Reno, Nevada.

NO BACK WATER

One year ago we installed a Calco Automatic Drainage Gate on a surface water drain from a concrete road to creek. Previous to this installation we had trouble during periods of high water with water backing up through pipe onto our road. We have not been bothered with water since installation of gate. It has always worked satisfactorily.

THE SUNBURY WATER COMPANY,
Sunbury, Pa.

SAVE THEIR COST EVERY YEAR

I have installed a great many of your corrugated culverts of most all sizes since 1908. They have been in constant use as bridges and for irrigation and drainage; and they appear to be just as good as ever. As for the Automatic Gates, they work perfectly, and I consider they save their cost every year. The gates, properly installed, will do the work without any care.

C. A. KELLEY,
Berkeley, Calif

GRAVITY DRAINAGE

Cutting the Costs of Land Reclamation by the Use of Natural Forces

THE drainage of swamps and marshes, low-lying fields and other sodden areas and their protection against back-flow is one of the most productive forms of reclamation. The soil of such regions, consisting almost wholly of fertile silt, is in most instances much richer than that of the surrounding country, and, because of its level contour and the absence of obstructions, is more easily tillable. Reclaimed areas of this character are thus more valuable for agriculture than other farming lands in the vicinity.

Marsh or overflowed lands which were previously almost worthless are made highly productive by these methods in a very short time. Many instances are on record of land which was originally worth from five dollars to fifty dollars per acre attaining in two or three years valuations ranging from fifty to three hundrd dollars according to location and market conditions.

In nearly every instance the first measure consists in throwing up a dike or levee between the land to be reclaimed and the river, bay or other body of water which is its natural outlet. The dike serves to exclude the water from the river or bay that would otherwise re-flood the land in times of freshets or high tides; but, were it not pierced with openings to carry off the water which falls on the land as rain or flows upon it from higher ground, it would act as an impounding dam and defeat its own purpose. Therefore openings in the forms of pipes or sluices of sufficient area to care for the drainage are placed at the lowest points, and these drainage ways are provided with gates to prevent back-flow.

Calco Automatic Gate installed by City of Tulsa, Oklahoma. City Engineer Charles Schultz, who is shown standing by the gate, expresses himself as well satisfied with its workings and has since purchased additional gates of the same model for similar use.

Sometimes these gates are of the hand-operated type, and dependence is placed on a watchman or caretaker for their timely opening and closing. But this method is costly, laborious and more or less uncertain, so on nearly all present day projects of this character automatic gates of some type are being installed.

Calco Automatic Drainage Gate at outlet of a marsh-land reclamation project.

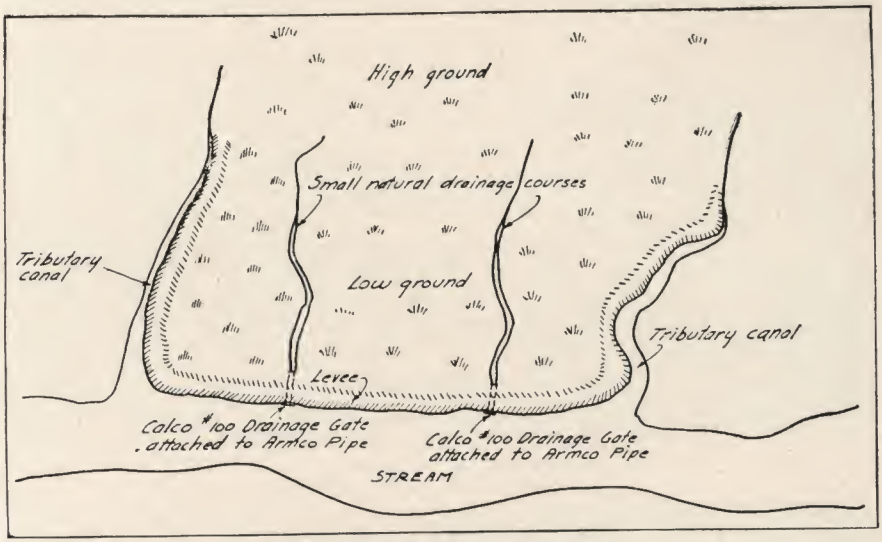
Wooden flap gates are often employed for this purpose. Sometimes these are hastily and crudely constructed from the materials nearest at hand and sometimes very carefully made by skilled workmen employing well selected lumber. But all alike are heavy and cumbersome and operate with a maximum of friction, delay and uncertainty. If the drainage ways remain dry for any considerable periods, wooden gates shrink and warp badly, then swell out of shape when the water again surrounds them. They are subject to rapid deterioration from decay, and, in some regions, to the destructive attacks of crabs and other borers. Because of excessive friction, such devices respond but tardily to change of water levels, and because of shrinkage and swelling, they are very far from water-tight. The result is that with wooden gates it is not possible to maintain low levels in the ditches on the reclaimed areas, and on important projects the automatic devices require much more assistance from pumping plants than should be the case.

What is needed is a form of automatic gate which works easily and surely, is practically water-tight and wholly dependable and durable under the conditions of its use. Such a device is the Calco Automatic Drainage Gate. It is made of cast iron for attaching to suitable lengths of Rust-Resisting Armco Corrugated Pipe. Its doubly-hinged shutter is so sensitive that a change of water levels of a fraction of an inch will open or close it. Once properly installed, it may be forgotten, for It Never Forgets.

With the Calco Automatic Drainage Gate the need for a pumping plant to supplement the gravity drainage system is reduced to a minimum and in thousands of cases is abolished altogether. It is only during long periods of high water with protracted local rains that the capacity of the ditches and soil may be taxed beyond their limit, and flood conditions

result. If this condition occurs often, or at times when crops are on the ground, a pumping plant is necessary, but in nearly all locations the capacity of the soil and the ditches will prove ample for those short periods when, on account of high levels in the river, the outlets through the levee are ineffective. The use of such a sensitive and efficient gate as that of the Calco Automatic Drainage Gate enables the land-owner to *utilize the force of gravity* for practically the whole of his drainage operations.

Some of the activities which afford opportunity for the effective employment of Armco Corrugated Pipes and Calco Gates are as follows:



Typical Marsh Land Reclamation Plan.

Automatic Operation of the Calco Gate.

Draining and protecting highway borrow pits. This is a very necessary measure for mosquito eradication.

Outlets of Armco Corrugated Storm Sewers at Clifton, Arizona, protected by Calco Automatic Drainage Gates.

Drainage Outlet in Canal Protected
by a Calco Automatic Gate.

Drainage of Streets and Roads

There are many locations where the gutters of a portion of a town or of a rural highway, lie below the high-water level of some nearby ditch, stream or other body of water. Fitting an Armco Culvert with an Automatic Drainage Gate on its outlet end solves any such problem. Under ordinary conditions, outflow proceeds freely from the gutters or the storm drains, but at times of heavy storms or freshets, when the level of the watercourse rises, the water is prevented from backing up through the pipes by the automatic action of the gates.

A notable instance of this kind of protection is in Clifton, Arizona, where several large corrugated storm drains terminate in the concrete wall of the river bank, as shown in the photograph on the preceding page, and are protected against the sudden rise of the stream by Automatic Drainage Gates.

Protection of Sewer Outlets

Sanitary sewers often need protection against back-flow from the ditches, streams or bays in which they discharge. Such outlets, if left unguarded, also afford entrance to rodents and other small animals which tend to fill the pipes with trash and clog the drains. Both these problems are completely solved by the installation of Calco Automatic Drainage Gates. Large numbers are in successful use for this purpose.

In many localities the drainage of borrow pits at the sides of highways or railroads is a constantly recurring problem. Often these are intersected by ditches or other waterways which dispose of the water at ordinary times, but act to flood the borrow pits when for any reason there are sudden rises in their levels. It is a simple matter to throw up a dike along the banks of such waterways and run through it a corrugated pipe with a Calco Automatic Gate on its outlet end. The pits will thus be effectively drained at ordinary times and protected from back-flow during high-water periods.

Calco Automatic Drainage Gate with Armco Corrugated Pipe at Fisk Beach, in Westbrook, Connecticut.

Reclaiming Salt Marshes

Remarkable results have been achieved in reclaiming the rich soils of many flat lands lying along our various sea coasts. Drainage problems in connection with these lands are unusually acute because of the continual backing up of tide waters and difficulty of keeping lands, once they are drained, free from the menace of overflow.

The success now being achieved in many of these districts is very largely due to the use of Armco Corrugated Pipe Drains inserted through the banks and with Calco Automatic Drainage Gates at the outlet ends.

Where galvanized corrugated pipe is to be placed in salt or brackish water the additional protection of a good asphaltic coating is recommended.

Draining Fresh Water Swamps

There are 79 million acres of swamp and overflow lands in the United States reclaimable by proper drainage. The total increased value of lands thus made available for agriculture is over one and one-half billion dollars.

In many of these regions there are no natural water courses and in order to provide outlets for impounding waters, construction of drainage canals is necessary. Where this is required it is customary to throw up embankments along the canals for additional protection in times of floods. The fields thus guarded are often ditched and the surface waters carried to a conveniently located drain. By introducing an Armco Corrugated Pipe between the ditch and the canal, equipping the canal end of the pipe with a Calco Automatic Drainage Gate and handling all field drainage through this, all danger from flooding the fields by backing up of the canal water is abolished.

In numerous other locations fresh water swamps or marshes abut natural lakes or streams. Vast areas of rich land are being reclaimed from such conditions by the erection of levees and the installation of corrugated pipes with automatic gates.

Calco Automatic Gates installed by the Nevada Highway Department at the point where the Peoples' Drainage Ditch, which drains the Truckee Meadows, enters the Truckee River.

48-inch Calco Automatic Gate at Lovelady, Texas, Carrying Surplus Water from Cotton Fields Through Flood Protection Levee.

Abolishing the Mosquito Nuisance

Since the discovery of the malignant nature of the mosquito and the fact that its elimination insures freedom from yellow fever, malarial fever and similar scourges, the importance of permanently draining swamps, lagoons and stagnant pools, thereby destroying the breeding places of this pest, has been clearly proven.

In hundreds of places this praiseworthy work has been greatly expedited and its results rendered lasting by the use of this simple and durable drainage and protection equipment. Incidentally, large and valuable areas are reclaimed for the production of food crops.

Grain Crop on Reclaimed Marsh Land.

Up-building Marsh Lands by Silt Control

The methods adopted to the drainage and development of the salt and fresh marshes are in general the same as those applied to river bottom land which is only occasionally over-flowed. On an area of considerable size a system of ditches is necessary to carry the drainage water to a main ditch or sump just inside the dike.

Calco Automatic Drainage Gates have been used for this work in hundreds of instances. In some cases where the land was too low and swampy to be reclaimed in this fashion because of lack of outlet facilities and where the drainage water carried considerable quantities of silt, an embankment pierced with pipe and gates has been used deliberately to flood the swampy area time after time with the result that silt deposit has finally raised the level of the territory until normal drainage became practicable.

The possibility of this method depends upon the frequency of overflow and the silt content of the flood waters. In some locations this brings about a very rapid rise in land levels—at the rate of several inches per year.

Small Marshes and Low Spots in Fields

The methods suggested above for draining swamps can be used with economy not only for large areas, but even for a very few acres. The cost of the pipes and gates is small and the building of an earth embankment can often be accomplished economically with no other tools than teams and scrapers, or on very small jobs, with picks and shovels. In many instances the improvement effected by the drainage and protection from back-flow of a comparatively small area in a cultivated field is actually worth many times more than the value of the reclaimed land for crop raising. Such marshy areas are serious obstructions to plowing, hauling and other field operations. One must always drive *around* them, or find some means for safely bridging them so that the cultivation of the remainder of the field is much more laborious and costly than need be. With the muddy spot well drained and made passable for teams and machinery, the entire tract will be handled more cheaply than the higher portions alone. And a breeding place for mosquitoes, frogs and water snakes will be permanently abolished.

Armco Culvert and Calco Automatic Drainage Gate installed by the Roosevelt Water Conservation District, Arizona. Flood water in the borrow pits behind the canal bank had previously done serious damage; but this installation proved a complete remedy.

Draining Over-irrigated Land

The practice of irrigating farm lands, even in the regions where more or less rain falls in the summer months, is proving highly profitable. Where rivers flow through large areas of low-lying land, these areas are irrigated by water taken out through headgates or raised by pumping from the rivers and distributed entirely by gravity. This ample supply, the ease with which it is secured, and the resulting low cost of the water, makes a constant temptation to over-irrigate. Formerly it was necessary to maintain pumping plants at low points in order to rid the fields of this surplus water by pumping it back into the rivers, in spite of the fact that in the majority of cases it would drain off itself when the rivers were at low stages.

The problem resulting from this situation was, of course, the prevention of back-flow when the river levels rose—a problem now completely solved by the use of corrugated pipe and Automatic Gates.

Protecting Drainage Outlets

Where drainage terminals are constructed of tile or other brittle material, the undermining of such outlets by water is a source of continual expense and annoyance. Naturally when such undermining occurs the tile drops and breaks. Erosion follows and presently another tile is undermined, broken off and the usefulness of the drain becomes more and more impaired. Small animals fill the pipes with trash and rubbish and the drain shortly becomes clogged and useless.

Prevention of such conditions is perfectly simple. By the use of fourteen or sixteen feet of Armco Corrugated Pipe at the outlet end of the tile drain, and fitting the pipe outlet with a Calco Automatic Drainage Gate, possible destruction of tiles by undermining or by freezing is eliminated. The outlet being automatically closed, except when there is running water in the drain, animals are kept out, as is also the flood water from the stream.

Maintaining Pond Levels

Under low heads the Calco Automatic Drainage Gate can be used to take the place of a slide gate by equipping it with an eye bolt so that a chain can be attached for raising and lowering as shown by the photographs.

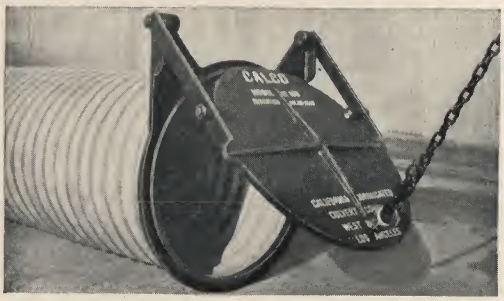
Many satisfactory installations of this type consist of lengths of Armco Corrugated Pipe equipped with Calco Automatic Gates on both ends.

When draining the land the gate on the inside of the levee is kept open by means of a chain and lever, and the gate on the outside end is allowed to work automatically. Thus as the water falls on the outside of the levee, it is automatically drained from the land. If it is decided to retain the water on the land and to add to it as opportunity offers, the operation is simply reversed.

Such an installation is practically an automatic pump working without power or supervision. It is a perfect arrangement for maintaining fixed levels in duck ponds, log ponds and upon marine lakes at seashore parks.

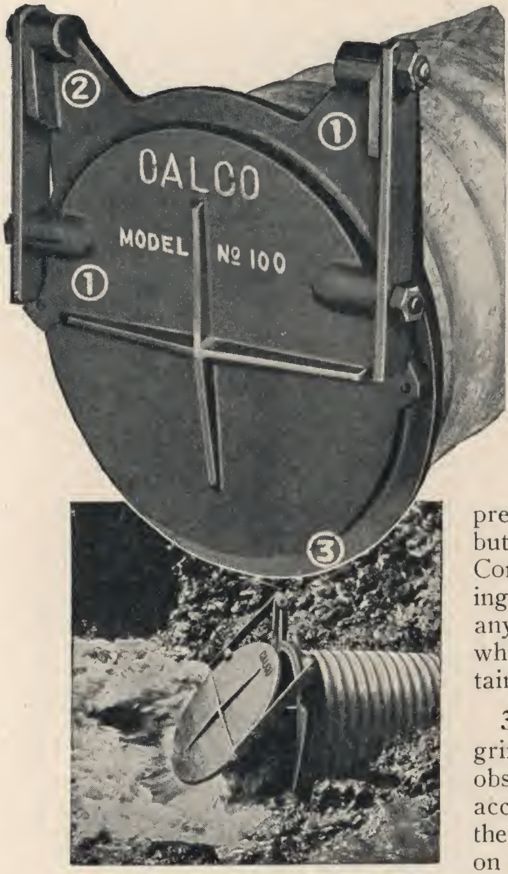
Air Vents for Pipes with Gates at Both Ends

In order to prevent damage from water-hammer it is essential to provide air-vents for pipes upon which gates are installed at both ends. This is because there must be an outlet for air which is entrapped when one of the gates is slightly open, admitting water, while the other gate is closed.



Eye-Bolt and Chain for Opening the Calco Gate when Inflow is Desired.

Constructional Advantages of the CALCO GATE



The Calco Automatic Drainage Gate is not an ordinary valve; it is truly automatic.

The construction of the Calco Automatic Drainage Gate is simple, yet remarkably efficient. There are three principal features that are responsible for its effective operation.

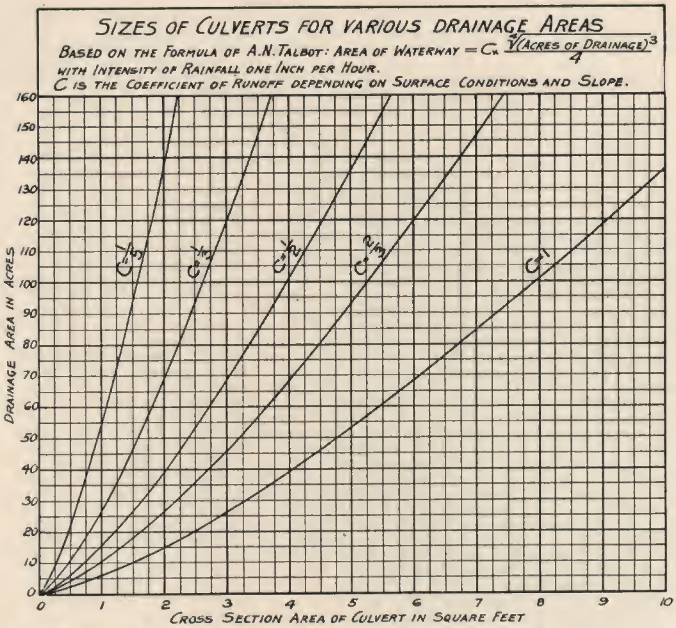
1. The Double Hinge—The shutter or flap is hinged not only at the tops of the standards but also at the points where the arms are attached to the shutter.

2. Flexible Bearings—These, together with the double hinge, allow the shutter to be moved forward by water pressure, not only at the bottom, but to some extent at the top also. Consequently when the pipe is flowing full the gate constitutes hardly any obstruction, and practically the whole capacity of the pipe is obtained.

3. Water Tight Seat providing grinding surfaces that grind out obstructions when in operation. The accurate machine fit, together with the very desirable play of the cover on the seat, that results from the flexibility of the construction, gives a slight grinding motion which grinds away any rust, dirt or barnacles adhering to these surfaces, and thus keeps them in good working condition.

Calco Gates are made in sizes from eight (8) to eighty-four (84) inches, equipped with any desired length of pipe. Thousands of them are in satisfactory use.

Our Engineers are at your service to show how Calco Gates can help solve your drainage and irrigation problems.



The factor C depends upon the contour of the land drained, and the following values are recommended for various conditions of topography.

c = 1, for steep and rocky ground with abrupt slopes.
c = ⅔, for rough hilly country of moderate slopes.
c = ½, for uneven valleys, very wide as compared to length.
c = ⅓, for rolling agricultural country where the length of the valley is three or four times the width.
c = ⅕, for level districts not affected by accumulated snow or severe floods. For still milder conditions decrease C; but increase C for steep side slopes or where the upper part of the valley has a much greater fall than the channel of the culvert.

EXAMPLE—Required the cross section area of a corrugated pipe suitable for draining 90 acres in level country. Rainfall is 2 inches per hour. Taking one-fifth as the value of C, locate the intersection of the 90-acre line with the first curve; then trace directly down to the base line and find the area 1.4 square feet. This area corresponds to 1 inch rainfall per hour and to find the required area multiply the area found by a given number of inches of rainfall, which gives the area of pipe 2.8 square feet. To find the diameter of the pipe in inches see table of areas below. The nearest stock size is a 24-inch pipe with an area of 3.14 square feet.

	CROSS SECTION		DRAINED AREA IN ACRES		
	Diameter of Pipe	Area of Culvert in Square Feet	Mountainous Country C = 1.0	Rolling Country C = ⅓	Level Country C = ⅕
Table indicating areas that will be properly drained by corrugated pipes of various diameters when land is mountainous, rolling or level. Basis one inch of rainfall per hour.	10-inch	.545	2.8	12.2	24.1
	12 "	.785	4.6	19.9	39.3
	15 "	1.227	8.3	36.1	71.4
	18 "	1.767	13.6	58.7	115.8
	21 "	2.405	20.4	88.5	174.7
	24 "	3.142	29.2	126.3	249.5
	30 "	4.909	53.0	230.0	452.5
	36 "	7.068	86.2	372.0	736.0
	42 "	9.621	130.0	562.0	1111.0
	48 "	12.566	185.3	802.0	1585.0
	54 "	16.000	256.0	1108.0	2190.0
	60 "	19.635	335.3	1454.0	2870.0
	66 "	23.760	434.0	1875.0	3710.0
	72 "	28.274	546.0	2365.0	4660.0
	78 "	33.183	676.0	2925.0	5780.0
	84 "	38.484	825.0	3570.0	7030.0

For other intensities of rainfall than 1 inch per hour, multiply the figures arrived at by the above diagram by the number of inches assumed.

The most common mistake in installing drainage pipes is failure to provide sufficient capacity. Too small a pipe will always cause trouble because of delayed drainage and may even result in serious erosion or a complete washout.

Quantity of Water Delivered by Area

In determining the quantity of water delivered by a given area, the following factors should be considered:

> Computations should be based on a maximum hourly precipitation. U. S. Government figures do not always give the rainfall for shorter than 24-hour periods. Proper allowance should be made if violent thunderstorms or cloudbursts are frequent.
>
> Long narrow watersheds deliver water more slowly than square or fan-shaped areas.
>
> The water drains more rapidly in hilly sections with steep slopes.
>
> Vegetation absorbs water and retards flow.
>
> A flat grade below the pipe will tend to retard the flow.
>
> A high embankment permits impounding the water, thus furnishing a head that will increase the flow.

In Talbot's Formula, the factors mentioned above are taken care of by a coefficient C which varies as shown under the table on the opposite page from 1/5 for level districts to 1 for fan-shaped, steep, barren soils.

Calco Automatic Drainage Gate Awaiting Installation on a Large California Ranch Consisting Mostly of Reclaimed Land.

Burkli-Ziegler Formula

$$\left\{\begin{array}{l}\text{Cubic ft. per sec. per} \\ \text{acre reaching culvert}\end{array}\right\} = \left\{\begin{array}{l}\text{Average cu. ft. rain-} \\ \text{fall per second per} \\ \text{acre during heavi-} \\ \text{est fall}\end{array}\right\} \times C \sqrt[4]{\frac{\text{Ave. slope of ground in ft. per 1000 ft.}}{\text{No. of acres drained}}}$$

C— .75 For paved streets and built up business blocks.
C— .625 For ordinary city streets.
C— .30 For villages with lawns and macadam streets.
C— .25 For farming country.
One inch rainfall per hour per acre = one cubic ft. per second per acre.

DISCHARGE IN CUBIC FEET PER SECOND

From Burkli-Ziegler's Formula: $Q = A \times I \times C \times \sqrt[4]{\frac{S}{A}}$ based on intensity of rainfall. I = inches per hour, where: Q = runoff in sec. ft., A = area of drainage in acres, C = coefficient of runoff depending on surface conditions, S = average slope of area toward the drain in ft. per thousand.

In the following table I = 1 inch per hour.

Area in Acres	Fall 5 Ft. in 1000		Fall 20 Ft. in 1000		Fall 50 Ft. in 1000	
	C=.30	C=.25	C=.30	C=.25	C=.30	C=.25
1	.45	.37	.63	.53	.80	.67
2	.75	.63	1.07	.89	1.34	1.12
3	1.02	.85	1.44	1.20	1.81	1.51
4	1.25	1.06	1.79	1.50	2.3	1.88
5	1.50	1.25	2.1	1.77	2.7	2.2
6	1.72	1.43	2.4	2.0	3.1	2.5
7	1.93	1.61	2.7	2.3	3.4	2.9
8	2.1	1.77	3.0	2.5	3.8	3.2
9	2.3	1.94	3.3	2.7	4.1	3.5
10	2.5	2.1	3.6	3.0	4.5	3.7
20	4.2	3.5	6.0	5.0	7.5	6.3
30	5.8	4.8	8.2	6.8	10.2	8.5
40	7.2	6.0	10.2	8.5	12.7	10.6
50	8.4	7.0	12.0	10.0	15.0	12.5
60	9.7	8.1	13.7	11.4	17.3	14.4
70	10.9	9.1	15.4	12.9	19.3	16.1
80	12.0	10.0	17.0	14.2	21.4	17.8
90	13.1	10.9	18.6	15.5	23.5	19.6
100	14.2	11.8	20.1	16.7	25.3	21.1
200	23.9	19.9	33.7	28.1	42.6	35.5
300	32.4	27.0	45.9	38.2	57.6	48.0
400	40.2	33.5	56.6	47.2	71.4	59.6
500	47.3	39.4	67.0	55.8	84.4	70.4
600	54.0	45.0	76.8	64.0	96.9	80.7
640	57.2	47.7	80.6	67.2	101.7	84.9

The Burkli-Ziegler Formula

The Burkli-Ziegler formula given with a handy chart on the opposite page, is excellent for the determination of maximum run-off for small watersheds. With precipitation figures for the territory, and a good contour map, with contour interval, of 5 to 10 ft., a close determination can be made of sizes of culverts to ensure ample capacity.

Rough Calculations of Run-off

It should be noted that these methods of determining culvert capacity involve many variable factors. Therefore they should always be checked with the results of field inspections.

In many cases, the size of previous drainage structures used, or the size of structures in use to drain similar areas in the same territory, offer a more convenient means of determining the size of culvert needed.

Sample Calculation

A low area of 20 acres has to be drained. The average slope is 20 feet in 1,000. Precipitation figures show a maximum rainfall of 2 inches per hour. The run-off coefficient for this territory is .25. Inspecting the chart on page 16, giving discharge in cubic feet per second, we find that 20 acres with the slope of 20 feet per 1,000 and rainfall 1 inch, discharge 5.0 cubic feet per second.

For maximum rainfall of 2 inches per hour the discharge will be 10.0 second feet.

By consulting the table on page 18 it is found that a 21-inch Armco Corrugated Pipe installed at a 3 per cent slope is necessary to drain this area.

Calco Gates Protecting Drainage Outlets on the Merced Irrigation District.

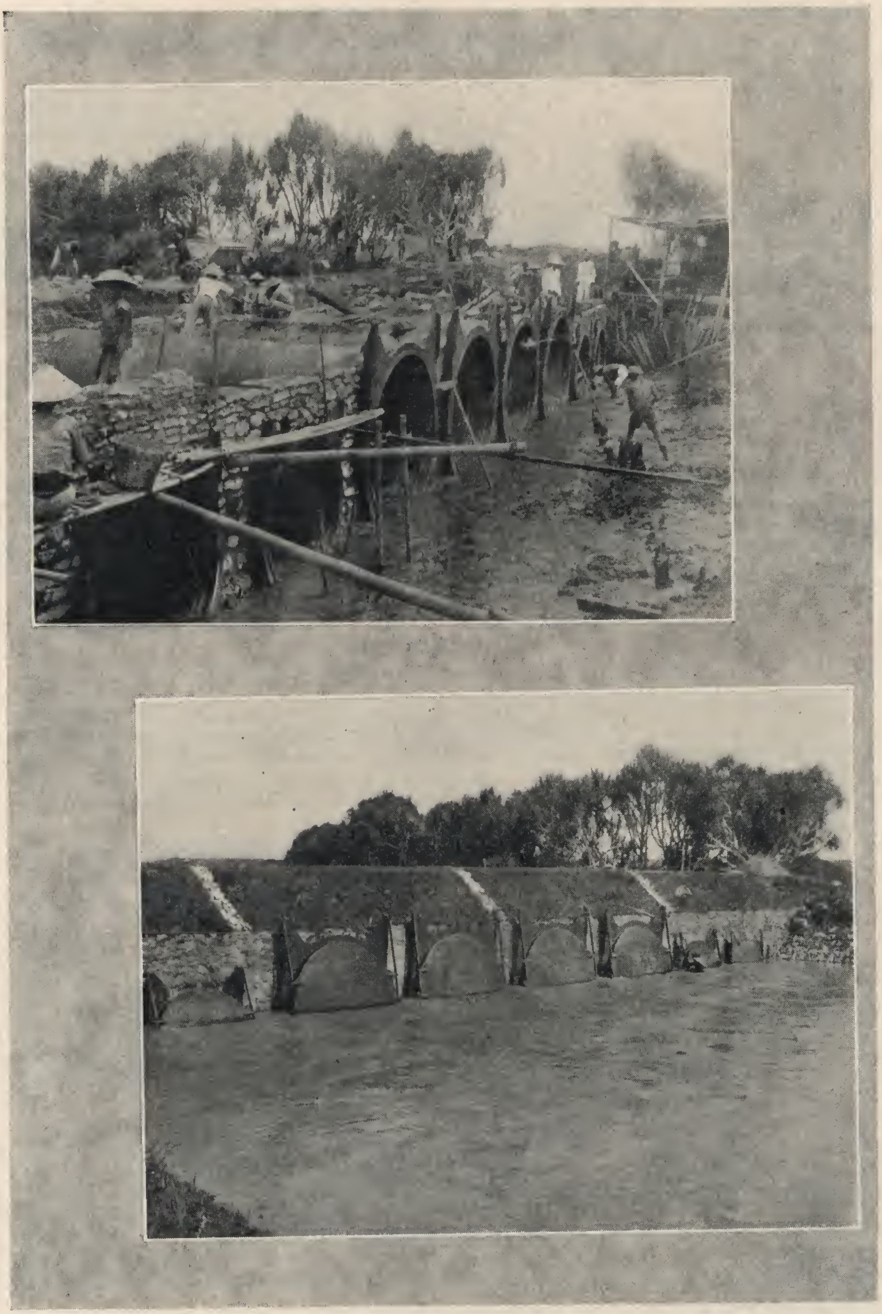
Capacities of Corrugated Pipe Straight End Wall Entrance. Length 30.6 ft. Discharge in Cubic Feet per Second.

Drop in Ft. in 100 Ft.	Head on Pipe in Feet	12 inch	*15 inch	18 inch	*21 inch	24 inch	30 inch	*36 inch	*42 inch	*48 inch	*54 inch	*60 inch	*66 inch	*72 inch	*78 inch	*84 inch
.033	.01	0.31	.52	.79	1.13	1.54	2.57	3.92	5.60	7.62	10.0	12.8	15.9	19.4	23.4	27.7
.066	.02	.44	.73	1.12	1.60	2.17	3.64	5.55	7.92	10.08	14.2	18.0	22.5	27.5	33.1	39.3
.100	.03	.54	.90	1.37	1.96	2.66	4.46	6.79	9.70	13.2	17.3	22.1	27.6	33.7	40.5	48.1
.133	.04	.62	1.04	1.58	2.26	3.07	5.15	7.84	11.2	15.2	20.0	25.5	31.8	38.9	46.8	55.5
.166	.05	.69	1.16	1.77	2.52	3.44	5.76	8.77	12.5	17.0	22.3	28.5	35.6	43.5	52.3	62.1
.200	.06	.76	1.27	1.94	2.77	3.76	6.30	9.61	13.7	18.7	24.5	31.3	39.0	47.7	57.3	68.0
.233	.07	.82	1.37	2.09	2.99	4.07	6.82	10.4	14.8	20.2	26.5	33.8	42.1	51.5	62.0	73.6
.266	.08	.88	1.47	2.24	3.19	4.35	7.28	11.1	15.8	21.5	28.3	36.9	45.0	55.0	66.2	78.5
.300	.09	.93	1.56	2.38	3.39	4.61	7.72	11.8	16.8	22.9	30.0	38.3	47.7	58.4	70.2	83.3
.333	.1	.98	1.64	2.50	3.57	4.86	8.14	12.4	17.7	24.1	31.7	40.4	50.3	61.5	74.0	87.8
.666	.2	1.39	2.32	3.54	5.05	6.87	11.5	17.5	25.0	34.1	44.7	57.1	71.2	87.0	104	124
1.00	.3	1.70	2.84	4.33	6.18	8.42	14.1	21.5	30.7	41.8	54.8	69.9	87.1	106	128	152
1.33	.4	1.96	3.28	5.00	7.14	9.72	16.3	24.8	35.4	48.2	63.3	80.7	106	123	148	175
1.66	.5	2.19	3.67	5.59	7.98	10.9	18.2	27.7	39.6	53.9	70.7	90.3	112	137	165	196
2.00	.6	2.40	4.02	6.13	8.75	11.9	19.9	30.4	43.4	59.1	77.5	98.9	123	158	181	215
2.33	.7	2.59	4.34	6.62	9.45	12.9	21.5	32.8	46.9	63.8	83.7	106	133	163	196	232
2.66	.8	2.77	4.64	7.07	10.1	13.8	23.0	35.1	50.1	68.2	89.4	114	142	174	209	248
3.00	.9	2.94	4.92	7.51	10.7	14.6	24.4	37.2	53.1	72.3	94.9	121	151	184	212	263
3.33	1.0	3.10	5.19	7.91	11.3	15.4	25.7	39.2	56.0	76.2	100	127	159	194	234	277
3.66	1.2	3.40	5.69	8.66	12.4	16.8	28.2	43.0	61.3	83.5	109	140	174	213	256	304
4.66	1.4	3.67	6.14	9.36	13.4	18.2	30.5	46.4	66.3	90.2	118	151	188	230	277	328
5.33	1.6	3.92	6.57	10.00	14.3	19.4	32.6	49.6	70.8	96.4	126	161	201	246	296	351
6.00	1.8	4.16	6.96	10.60	15.2	20.6	34.5	52.6	75.1	102.0	134	171	213	261	314	372
6.66	2.0	4.38	7.34	11.20	16.0	21.7	36.4	55.5	79.2	108	142	180	225	275	331	392
7.33	2.2	4.60	7.70	11.74	16.8	22.8	38.2	58.2	83.1	113	148	189	236	289	347	413
8.00	2.4	4.80	8.04	12.25	17.5	23.8	39.9	60.8	86.8	118	155	198	246	301	362	430
8.66	2.6	5.00	8.37	12.81	18.2	24.8	41.7	63.0	90.3	123	161	206	257	314	377	448
9.33	2.8	5.19	8.69	13.24	18.9	25.7	43.1	65.6	93.7	128	167	213	266	325	392	465
10.00	3.0	5.37	8.99	13.70	19.6	26.6	44.6	67.9	97.0	132	173	221	276	337	405	481
10.66	3.2	5.55	9.29	14.26	20.2	27.5	46.1	70.2	100.2	136	179	228	285	348	418	497
11.33	3.4	5.72	9.57	14.60	20.8	28.4	47.5	72.3	103.5	141	184	235	293	359	431	512
11.66	3.5	5.80	9.71	14.80	21.1	28.8	48.2	73.4	105.0	143	187	239	298	364	438	519

NOTE:—This table is based on the formula $Q = 3.10\ D^{2.31}\ H^{.50}$ for corrugated pipe in which Q = discharge in cubic feet per Sec. D = diameter of pipe in feet and H = head on pipe in feet.

*—No experiments made on these sizes—Quantity computed by formula.

This capacity table is compiled from figures obtained through a series of tests made by the U. S. Bureau of Public Roads at the Hydraulic Testing Plant of the University of Iowa. Note that capacities are for 30.6 ft. length of pipe.



Armco Culverts and Calco Automatic Gates Caring for the Entire Outflow of an Oriental River and Protecting it from Tidal Floods.

WHAT USERS SAY *of the* Calco Automatic Gate:

Norborne, Missouri, June 18, 1926.

We used two 60-inch pipes with automatic gates attached as an outlet from a certain one of our lateral ditches into the main ditch of our drainage system on account of the fact that we were afraid that at times the water level would be so high in the main ditch that it would cause back water in the lateral and possibly overflow some of the lower lands.

We have found the use of these pipes with the gates attached to be very satisfactory so far. These pipes were installed in 1923.

NORBORNE LAND DRAINAGE DISTRICT COMPANY,
By J. H. FRANKEN, *Secretary.*

San Rafael, Calif., Jan. 21, 1926.

Having installed your gates over a period of ten years from 1916 to 1926 in our work of mosquito abatement, I can say that they rank supreme among all other methods of control used by us in the eradication of breeding areas for this pest. When properly installed they work without further attention and I can recommend them as an efficient working device.

MARIN COUNTY MOSQUITO ABATEMENT DISTRICT,
By N. M. STOVER, *Supt.*

Carson City, Nev., Feb. 23, 1926.

The Calco Automatic Gates which we purchased from you several years ago were installed on one of our State Highway projects near Minden where it was possible to drain the borrow pits into existing ditches, thus saving the expense of constructing an elaborate system.

The satisfactory performance of the Calco Gates enables me to recommend them highly to anyone needing such a device.

GEO. W. BORDEN, *State Highway Engineer,*
By P. L. BONEYSTEELE, *Maintenance Engr.*

Oakdale, Calif., February 20, 1926.

With reference to the Calco Automatic Drainage Gates and Slide Headgates purchased from you during the past 12 years, have to advise that they have given perfect satisfaction and are in excellent condition and in use at this time.

OAKDALE IRRIGATION DISTRICT,
By M. P. KEARNEY, *Secretary.*

Sacramento, Calif., Feb. 2, 1926.

We take this opportunity of writing you a little message to tell you of the success we have met with in the operation and maintenance of your Calco Automatic Drainage Gates and Slide Headgates. These gates attached to the Armco Corrugated Pipes have been giving us wonderful service year in and year out at our ranches located on Sherman Island, California. In all forms of irrigation and reclamation work these types of gates combine all the best and necessary features for the performance of the work for which they are designed.

W. A. CURTIS ESTATE COMPANY,
By W. I. HECHTMAN, *V. P.*

Hydraulic Tests of Calco Automatic Drainage Gates

Excerpted from Report by Prof. Floyd A. Nagler,
Associate Professor of Mechanics and Hydraulics,
State University of Iowa

During the month of November, 1922, the Hydraulic Laboratory of the State University of Iowa conducted a series of tests to determine the amount of head lost by water discharging through "Calco" automatic drainage gates. The tests were performed at the request of the Armco Culvert and Flume Manufacturers' Association, and the gates 18, 24 and 30 inches in diameter were furnished for this purpose from commercial stock on hand at their mills in Middletown, Ohio.

The gates were tested in the canal of the hydraulic laboratory. Each gate was attached to a ten or twelve foot length of Armco corrugated iron pipe of the same diameter as the gate. The pipe was installed in the flume by building a water-tight bulkhead at the upstream end and constructing a second water-tight bulkhead a few inches upstream from the down-stream end of the pipe to which the gate was attached. All of the water passing down the canal was thus forced to pass through the pipe and the gate. The quantity of water was measured by means of a five-foot sharp crested weir located in the canal twenty-five feet upstream from the pipe. The quantity of water passing through the gate was regulated entirely by the head gate at the upstream end of the canal. In order to test the gates when operating both submerged and freely in the air, a bear trap weir was installed across the canal about fifty feet downstream from the gate by regulation of which any desired water surface elevation could be obtained. The space between the two bulkheads was utilized by the observers. Along the wall of the canal there was installed piezometers connecting to the pipe and the hook gauges by means of which the water levels, upstream and down-stream from the bulkheads were measured. The photograph in Fig. 3 was taken looking down upon the testing section just described. The bulkhead at the upstream end of the pipe is in the foreground, while the downstream bulkhead hides the view of the Calco gate which is being tested.

The loss in head caused by the Calco gate was measured by making two tests with identical quantities of water flowing through the gate; in the first test the shutter of the gate was raised clear of the water so as to make it ineffective and in the second test the

Fig. 1. Pipe Discharging Freely into Air when Calco Gate is Attached.

Fig. 2. 30-inch Calco Gate on End of 30-inch Pipe when 29.8 c. f. s. is Discharging with Outlet Practically Submerged.

shutter was released so that the gate acted as it normally would. If the pipe was flowing full, any difference in piezometer readings or in the level of water surface upstream from the entrance to the pipe or in the total amount of head lost by the water as it passed through the pipe and gate, indicated the amount of head loss caused by the gate. In this manner each gate was tested with the water at the outlet and discharging freely into the air and with the outlet entirely submerged, maintaining a uniform discharge through the apparatus for all four experiments. Other experiments were then performed with different quantities of water flowing through the gate in order to obtain about twenty-five experiments on each gate with velocities of flow covering a range of from one to eight feet per second.

Figure 1 shows a picture taken of the 30-inch Calco gate when water was discharging freely into the air at the rate of 29.8 cubic feet per second. The cast-iron shutter can be seen riding freely on the issuing jet hardly obstructing the flow of water at all, with a loss in head caused by this gate of less than .01 feet. Figure 2 shows the 30-inch gate discharging the same quantity of water—29.8 c. f. s.—but the water level downstream from the gate has been raised so that the outlet is almost submerged. The shutter of the

Fig. 3. Testing Pit During Process of Testing.

gate appears as though it were almost floating on the water surface and apparently offers but little resistance to the jet issuing from the pipe. The loss in head caused by the gate was but .08 foot. The loss in head is much greater with the submerged outlet than when the water discharges freely into the air, but nevertheless it is quite insignificant in magnitude. The greater loss with submerged conditions is due to the fact that the gate offers a greater resistance to the jet issuing from the submerged pipe since the direction of the jet is practically horizontal, whereas the upper surface of the jet has an appreciable component of velocity vertically downward when it issues freely into the air.

The final results of the experiments are shown in the diagram in Fig. 4. The curves on the diagram show the amount of head loss for different velocities of flow for each of the three gates tested, and are based on a submerged condition of outlet only. In no experiment was the measured loss greater than .01 ft. with the outlet exposed to the air.

Based on these experiments the following empirical formula was derived to express the loss in head through Calco gates of varying size and with different velocities of flow:

$$L = \frac{4v^2}{g} \times e^{\frac{-1.15v}{\sqrt{d}}}$$

L = Loss of head in feet.

v = Velocity of flow through gate in feet per second.

d = Diameter of outlet in feet.

e = Base of natural logarithms.

$\frac{v^2}{2g}$ = Velocity head of water in outlet.

Without further experimentation the accuracy of this formula for gates of other sizes than those experimented upon is somewhat questionable; however it is interesting to note that by this formula the maximum loss in head for a gate as large as 72 inches in diameter is .30 ft. when the velocity through the outlet is four feet per second.

It may be concluded from these experiments that the Calco gate in its hydraulic characteristics is all that the manufacturers have claimed for it. The small loss in head obtained through these gates demonstrates that their installation has but little effect on the discharged capacity of drainage outlets.

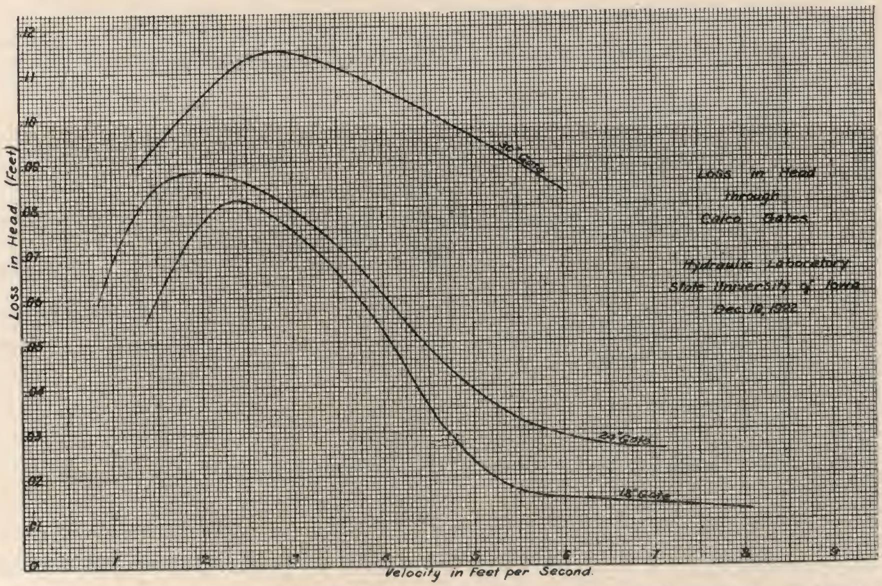
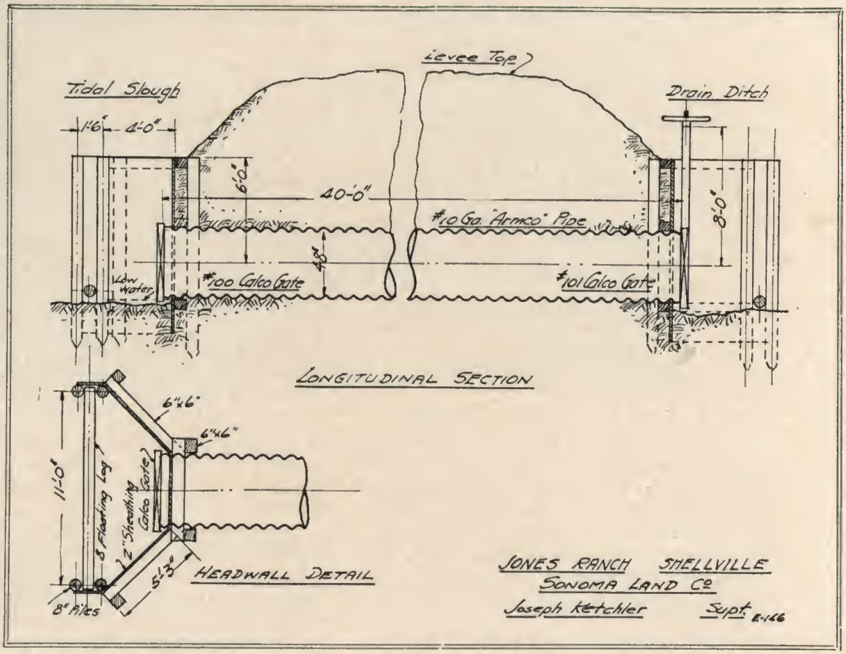
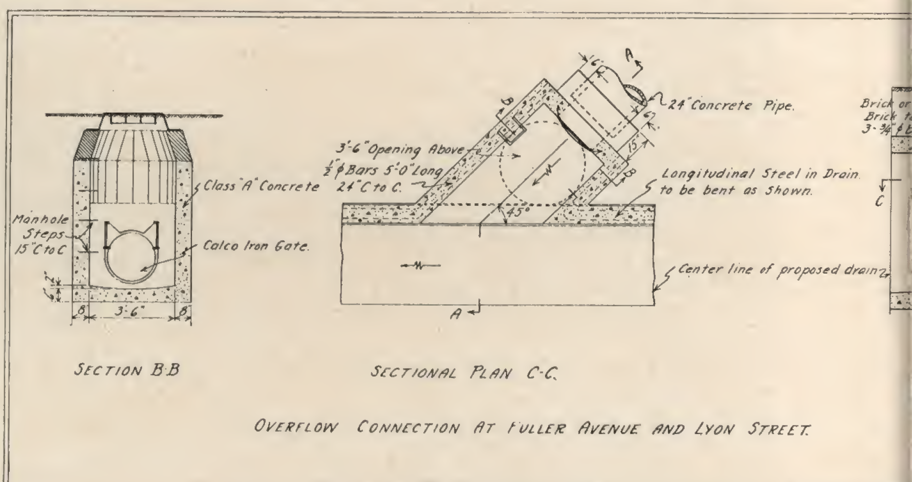


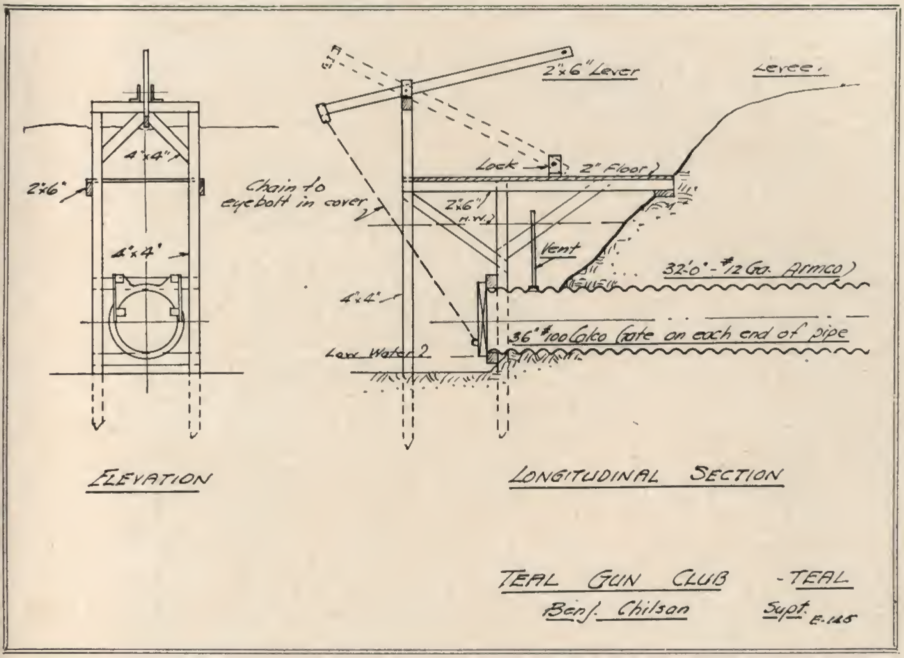
Fig. 4. Experimental Curves Showing Loss in Head Through Calco Gates 18, 24, and 30 Inches in Diameter for Different Velocities of Flow.



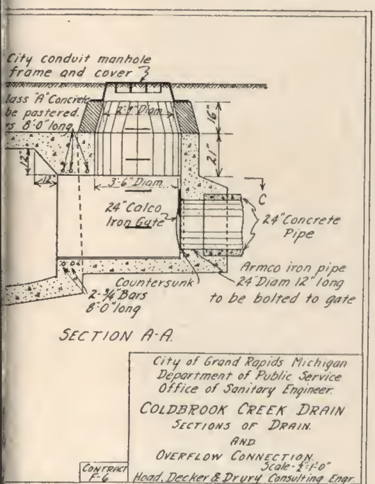
TYPICAL INSTALLATION DESIGN, EMPLOYING CALCO AUTOMATIC AND SLIDE HEADGATES.



INSTALLATION OF CALCO AUTOMATIC DRAINAGE GATES IN THE NEW SEWAGE SYS

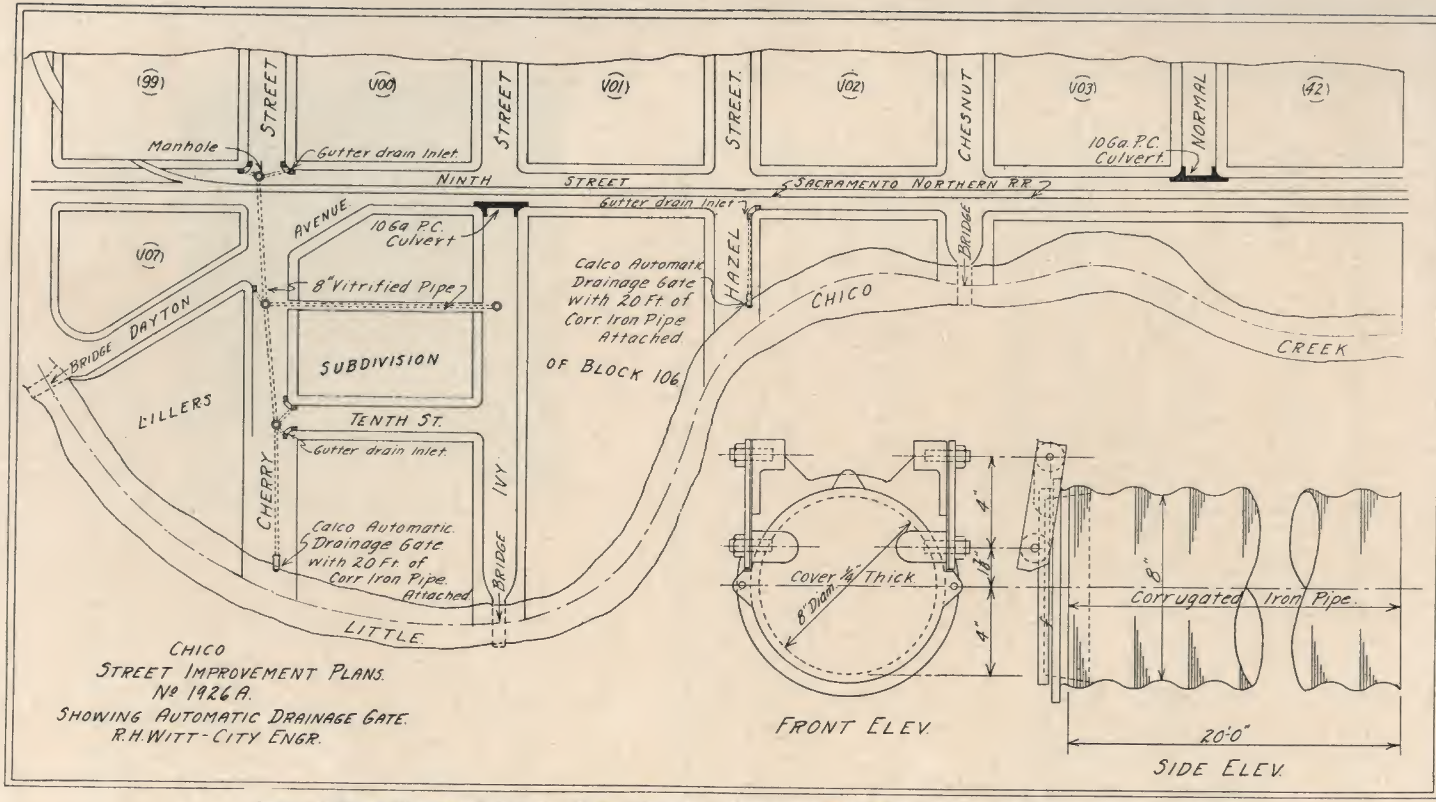


LEVER DEVICE FOR RAISING CALCO AUTOMATIC GATE UNDER LOW HEADS.



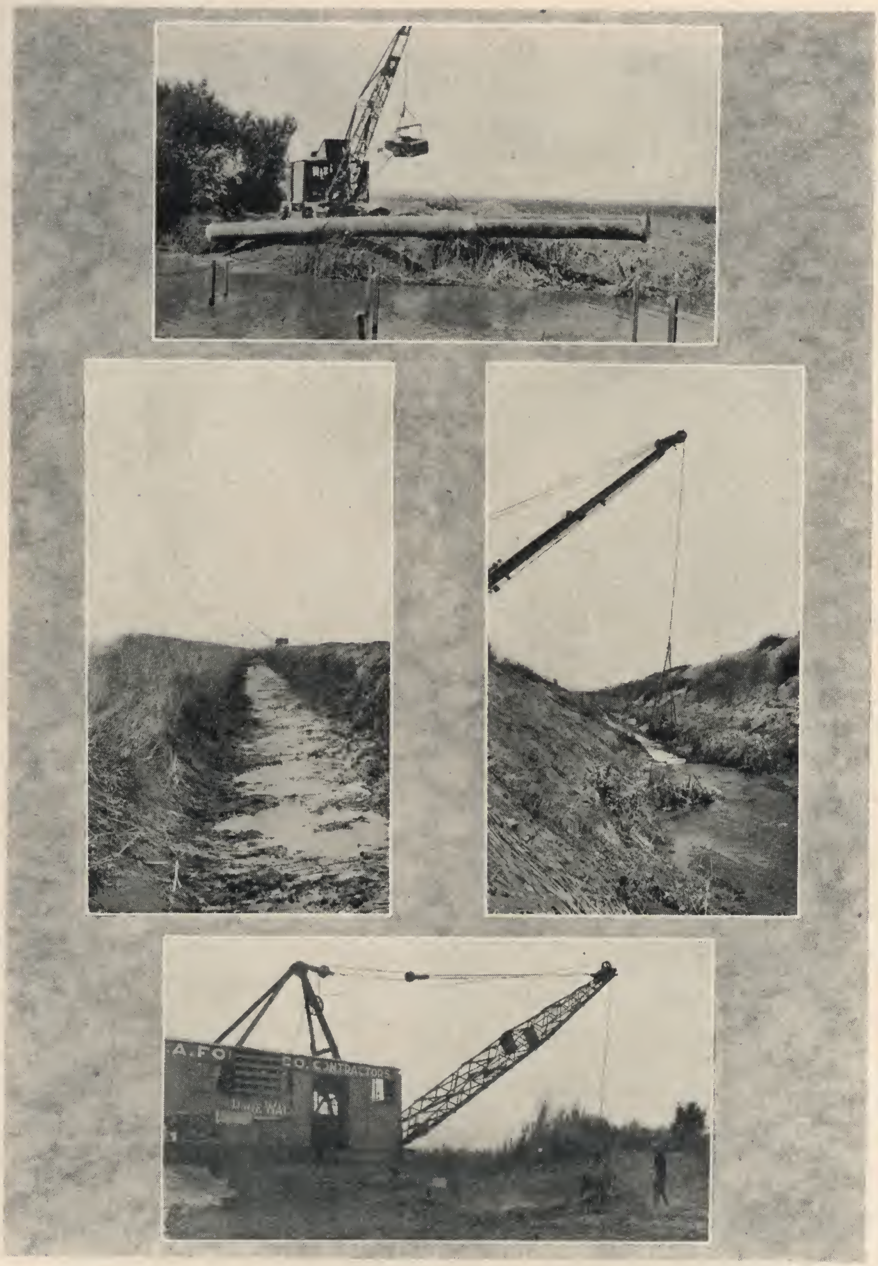
EM OF GRAND RAPIDS, MICHIGAN.

ONE OF THE CALCO GATES INSTALLED AS PER ACCOMPANYING DESIGN.



Outlet of Storm Drainage System at Chico, California. Backflow Prevented by Calco Automatic Drainage Gates.

Street Drainage Culvert Outlet, 8-Inch Diameter, Protected by Calco Automatic Drainage Gate.



Top—Showing the use of the Dragline for handling large Armco Corrugated Culverts. The pipe is lifted and placed in position, ready for the fill. *Left Center*—The Management of the Hastings Ranch of the California Packing Company, Rio Vista, California, has found the solution of cleaning their canals in the use of the Dragline. *Right Center*—Mr. R. W. Slattery of the Imperial Irrigation District, Imperial, California, uses the Clamshell quite successfully for cleaning operations. The Clamshell excavates the bottom of the canal, leaving the tules to grow on the sides. The shade thus afforded by the vegetation at the sides discourages further growth in the channel. *Bottom*—The Dragline is also used in activities of this kind for the placing of siphons or culverts and gates bodily into their positions after which the fill is placed over them.

Installation of Calco Gates and Corrugated Pipes in Reclaiming Marsh Land

Armco Corrugated Pipes fitted with Calco Automatic Gates or Calco Slide Headgates can be employed successfully in practically any location where it is practicable to maintain levees. It is true, of course, that the difficulties in connection with the use of these pipes and gates increase with the softness and wetness of the soil around them, but this is even more true with regard to any other structures built to serve the same purpose. Many of these alternative structures are altogether impracticable without fairly stable and unchanging foundations. In many locations stable foundations can be secured only at such expense as to make the development impracticable.

The use of large size gates and pipes (48″ to 84″) can be made safe and practical by the right methods of installation, in spite of the fact that these large sizes offer certain difficulties not met with in connection with the smaller ones.

It should be recognized that the satisfactory working of Calco Automatic Gates requires that they be placed vertically—that is, if the pipe slopes downward where the gate is attached, the shutter will not close tightly, and if it slopes upward it will not open until more water has accumulated behind it than would otherwise be necessary.

Method of Transportation of Calco Gates and Pipes

Calco Gates and pipes are delivered by boat, barge, dredger, wagon and truck, and sometimes floated and towed. The last method is advisable only where the pipe is made water-tight either by close riveting and soldering or dipping in asphaltic compound, this latter being necessary under especially corrosive conditions. When towing, the ends are closed by means of bolting down the covers of the gates or, if gates are not supplied, by tieing canvas heads to the ends of the pipes.

Convenient Use of Dredger in Installing

The dredger is brought to the site by digging itself in as it proceeds, making the levee. Sometimes it is towed through the channels as far as possible to get it to the site. Very small machines are skidded overland on slippers or skids.

When installing the pipe with dredgers a trench is simply dug and leveled off at the bottom by manipulating the bucket of the dredge. The pipe is laid in this trench and held level by means of stakes, then the dredger back-fills over the top of the pipe by carefully tamping in buckets of sand or mud. It is advisable, if there is any sand or sandy mud, to back-fill over the pipes with this material rather than to use very soft, blue mud. In back-filling over the pipes it is advisable to be careful with the bucket of the dredger so as not to get too much earth or mud dumped on the pipe at one time, until the back-fill has reached a level of about two feet over the top of the pipe.

When installing pipes in battery, care should be taken to see that they are far enough apart so that trash entering one pipe, or floating against the levee, when the pipes are installed, can not loop itself around the spacing between the culverts. This would form an obstruction to flow into both pipes affected. To avoid this condition, pipes should be placed at least 1½ diameter apart.

Pipes with automatic gates should be placed as deeply as possible in the levees. If it is possible to place them so that at low tide level the gates are entirely submerged, it should be done, as keeping the gates submerged greatly protects them from weathering and also keeps the trash that floats on the surface of the water from entering. Sometimes this can not be done on account

of silt conditions. But in all cases the gates should be low enough so that at extremely low tide the water is not lower than the bottom of the pipe.

By placing the gates deeply in the water, as mentioned above, they are protected from the greater part of the floating debris. Additional protection, such as floating logs, or screens should always be provided in front of drainage gates, to guard against floating debris and to protect them from being broken by heavy pieces of timber, or barges floating against them.

The height of the levee having been determined, its width is limited by the length of the dredger boom. The channel cut by the dredger would have to be at least two feet deeper than its hull. The side slopes of the levees will vary according to the material. Never, however, are they steeper than 1½ to one.

The settlement of the pipe is not quite as much as that of the levee as the pipe is generally installed in a cut. When the ground is drying out, however, it shrinks, sometimes as much as one foot per year for the first three years, and the pipes that are installed therein will settle nearly as much.

Three feet is about the normal shrinkage that should be expected after the ground has been draining for a period of about four years. Where the surface water that flows on to the reclaimed land carries considerable silt this shrinkage may be more than offset by successive silt deposits, so that the general level soon becomes higher than before the reclamation was begun.

The size of the pipe is determined by the rainfall runoff and the length of time required to drain the land. In many cases, reclaimed lands become completely submerged during the winter due to the rise in the river and sloughs adjoining these lands. Knowing the rate at which this river water recedes after flood periods, and the length of time one can allow for draining the lands, the sizes of gates can be determined.

When making levees in unreclaimed land it is usually the best practice to install gates at the ends of the natural drainage ditches and this makes it possible by investigating the flow in these channels to determine more accurately the sizes of structures required. When installing gates one must be very careful to see that the outlet ends are not so placed as to become silted up due to their discharging in very shallow water or into a channel where there is not enough velocity to carry off the silt. Whenever possible it is best to install the gates and pipes with their outlets discharging in ditches or deep canals. By keeping the levees well out near the deep water or so that at low tide there is not an accumulation of mud at the outlet side of the gates, the gates can be kept always free from silt. When the dredger is borrowing earth to build levees it should always take from the outside or tidal side rather than from the side to be drained.

When the gates are subject to wave action, such as when they discharge into a wide bay or into the ocean, a pile or concrete sea wall should be built in front of the gate and high enough to protect it from wave action and floating debris.

Most ditches should be cleaned and levees trimmed up about every three to five years, depending upon the amount of weed growth and debris that accumulates.

Locations in Soft Ground Where Some Type of Headwall Is Necessary

Where the levee is fairly stable no problem is presented. Ordinary care in installation is all that is necessary. Where the dike or levee is very soft or new some further precautions are desirable. If it can be done without too much trouble, a jacket of sand or gravel should be deposited under and around the corrugated pipe. This will afford a great deal better support, and under the conditions we are considering will be interpenetrated by the loam or silt which forms the body of the levee so as not to form a pervious area which would give opportunity for percolation of water along the outside of the pipe.

Such a jacket of sand or gravel is very useful under any of the conditions herein discussed. Where it can be

applied, it will in many cases constitute a complete solution. However, the fact has to be recognized that in a great number of locations it will be impracticable on account of difficulties encountered in securing and transporting the sand or gravel.

Headwalls are necessary with corrugated pipe and Calco Gates where the earth is very soft and apt to wash, and there is considerable current in the canal where they are installed. When headwalls are to be used they should not be installed at the time the gate is put in, but rather about six months later. The levees in the meantime will have been given a chance to shrink and the pipes to settle and become more firmly lodged. Headwalls in soft material should never be made of concrete as the weight of the concrete headwall will tend to bear on the pipe near the gate due to the slow sinking of the soft material surrounding such an installation.

Figure 1 shows a type of end protection which can be used when the ground is a little softer than that described above — not dense enough to support the drainage structure without the aid of some sort of headwall. A long sill "A" is placed directly under the ring of the gate behind the flange. Another piece similar to "A" is used as a header at the top as "B". These two timbers are tied together and clamped to the gate by means of threaded rods and nuts "D". Then the whole structure is planked at the back by means of planks "C". This type of headwall forms a good protection to the levee on both sides of the gate, and also a certain amount of buoyancy to help support the added weight of the cast iron ring and cover. It is good practice to install such a headwall with all gates and corrugated pipes, no matter what the conditions of the soil, because a headwall of this kind makes it possible to keep the corrugated pipe well buried in the levee material, thus keeping it from being exposed to the attacks of air, water, etc., from the outside, and also making a far better headwall than concrete because of its light weight and its tendency to buoy up the gate rather than to pull it down.

In some locations, where large pipes are placed in very soft ground, it will be well to use lines of posts, connected by plank stringers, at the sides of the pipes, to prevent displacement during the settling and shrinking of the embankments. These supports are made still more efficient if securely tied together across the tops of the pipes by wire rope or bolted stringers.

CALCO GATE INSTALLATIONS

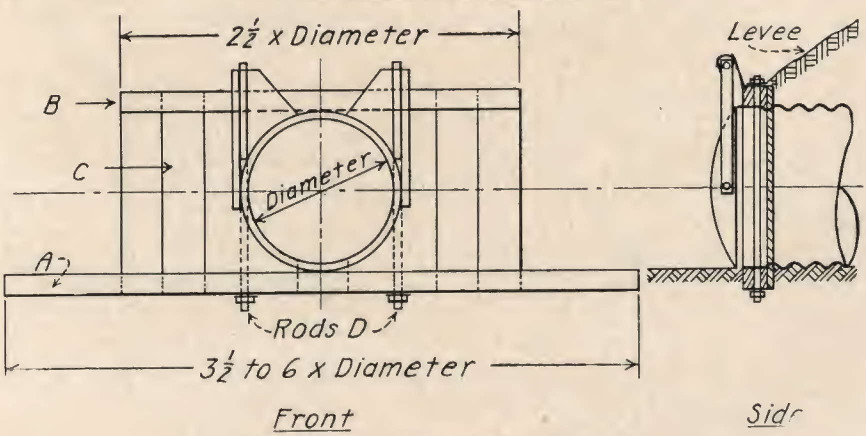


Fig. 1. Timber Headwall for Soft Ground.

The Most Soft and Unstable Foundations

Wherever a levee can be thrown up and eventually made to stay in place, an installation of a Calco Gate and corrugated pipe can be made without danger that the pipe or gate will be bent or made to settle so that it can not operate properly. In very soft mud it takes a long time for the levee to dry out finally so that it sustains itself and keeps from flattening out due to the pressure of earth. The first year that a levee is built in soft mud, it will gradually flatten and spread out and at the same time the water in the levee will drain and dry out so that after a certain length of time an equilibrium is reached, the levee being dry enough so that it does not spread out and slough at the toe, its weight having pushed out much of the water from the surrounding and underlying ground. It is sometimes necessary to keep adding to the levee until the movement of the soil has practically ceased.

Figure 2 shows a method of protecting the heavy gated end of the pipe from settling in soft, mushy soils. It is self-explanatory, the gate being laid on long sills "E," and sleepers "D" placed under these sills throughout the length of the pipe on about 3′ to 6′ centers. Then on the end where the gate occurs, these sleepers should be placed one next to the other and enough of them installed both ahead of the gate and behind to keep the outrushing water from undercutting the structure. These sleepers "D" should be bolted to the sills "E." Across the top of the pipe directly behind the gate should be placed a header "F" and the cut-off sheet piling "C" fastened by means of bolts to one of the sills at "D" and also the header "F." This provides both a cut-off wall, a headwall and a means of keeping the gate in line. If the ground is found to be of the quicksand nature, a brace can be installed as shown, and the whole structure sheet-piled by means of piling "B" and 'C'." When computing the amount of lumber to be used in such a protection, it would be advisable to provide just enough lumber under the gate casting to float the amount of weight in these castings; in other words, the buoyancy of the lumber should be equal to the weight of the ring and cover of the gate.

In every case the worst conditions of sloughing or spreading and flattening of the levees occur where they

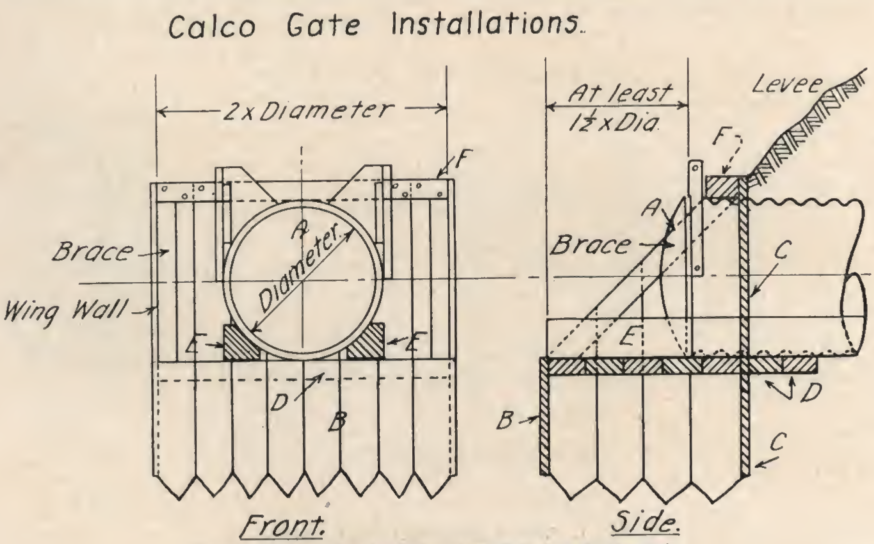


Fig. 2. Timber Headwall for Very Soft and Slushy Soil.

cross natural drainage channels. See Figure 3. For this reason when installing gates in locations where the mud is very soft, it is not advisable to put the gate directly in these natural channels. The better practice would be to build the levees around them and leave the natural outlets open for about a year. See "D" in Figure 3. During this time the natural drainage "A" would continue functioning and in the meantime the levee would be drying out and becoming more stable. When the point is reached where the levee seems to be sufficiently self-supporting to warrant installing a gate structure, it should be cut at a point "C" a little above the natural drainage channels where the ground is apt to be much more solid. The gate should be installed by carefully coffer-damming so that no excess water is sent rushing through the cut where the gate and pipe is to be placed. The gate in place, the cut in the levee should be covered over with the driest earth available at the site, then an artificial drain taking the place of the natural drain should be cut as shown at "B."

The next step would be to fill in that portion of the natural drainage channel between "B" and the point "D," and to extend the levee across it at "D." It will sometimes be advisable when the ground is exceedingly muddy to sheet-pile a certain distance across the mouth of the natural drainage canal before filling in the levee as shown at "E."

Regarding the use of a few large diameter structures rather than two or more smaller ones, it should be remembered that in places where the wall is exceedingly wet and like quicksand, a concentration of a large volume of water in one spot is apt to cause undercutting beneath the gate structure. Rather than concentrate this water in one place, it would be better to spread it along the length of the levee and discharge it at intervals of say from fifty to one-hundred feet, through smaller structures. Where the head of water is great enough to fill a large diameter pipe (48" to 84"), it would be great enough to undermine the soft under-strata directly under the gate structures. Rather than concentrate a large volume of water of this kind against one gate and attempt to have that gate function under a head high enough to fill the pipe in cases where the ground is very soft, it may be better to install several gates of somewhat larger diameter than would be necessary for capacity alone, and by so doing cut down the velocity of the discharging water.

Calco Gates and Armco Corrugated Culverts are so adaptable to varying conditions of use that sizes and methods of installation can always be selected to conform to any circumstances under which it is possible to maintain structures of any kind for purposes of drainage and reclamation.

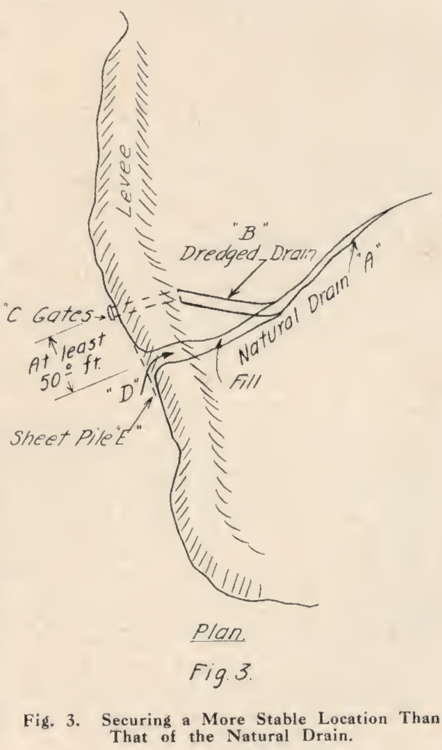


Fig. 3. Securing a More Stable Location Than That of the Natural Drain.

WHAT USERS SAY *of the* Calco Automatic Gate:

Chico, Calif., Feb. 2, 1926.

The Calco Automatic Drainage Gates and the lateral Slide Headgates we installed have just simply worked to perfection and have not given us the least trouble.

We are so impressed with them that we are now planning to use more of them, in fact at every possible point on our system.

You will hear from us again. We are indebted to you for supplying us with so much grief-proof material.

PHELAN-PARROTT IRRIGATION SYSTEM,
By J. D. HUBBARD, *Engr. in Charge.*

Gridley, Calif., Feb. 2, 1926.

We have a number of your Calco Gates installed, both the Automatic No. 100 and the Slide Headgate No. 101. These gates were installed in 1921 and are entirely satisfactory.

During construction we used several car loads of your pipe which after five years' use is almost as good as new.

We can recommend "Armco" products.

RECLAMATION DISTRICT NO. 833,
By M. J. RIFFE, *Manager.*

Oroville, Calif., Feb. 1, 1926.

With reference to the Calco Automatic Drainage Gates, there is hardly anything I can say as to their efficiency, as one look shows them to be automatic and 100 per cent efficient. Our experience with them has been very satisfactory.

WESTERN CANAL COMPANY,
By H. F. CAUTHARD, *Manager.*

Yemassee, S. C., January 14, 1926.

The Calco Automatic Drainage Gates you sold me a year or two ago are giving perfect satisfaction.

JAS. G. HUTSON.

Toledo, Ohio, Sept. 1, 1925.

We are now using your gates on a large dyke farm to let water in and out of Lake Erie. These dykes are 50 feet wide and 12 feet high, one mile long along the edge of Lake Erie and before we used your gates we would have to spend about $800.00 each year for pumping. This year with one gate we spent only about $25.00 for pumping.

STARR-THORNBERRY COMPANY.

Napa, Calif., Jan. 20, 1926.

Have been using the Calco Automatic Drainage and Headgates and Armco pipe for 12 years on our levee, with big results, and they are still in first-class condition.

STANLEY RANCH,
By MARTIN ZANINI, *Supt.*

Unreclaimed Land, Liberty Farms, Solano County, California. Note the rank growth of swamp vegetation.

Reclaimed marsh land of the Liberty Farms, Solano County, California, which yields two crops a year—one of barley and one of beans. After four years of reclamation, the land was brought to its present productive state.

Chart

for the

Solution

of

Kutter's Formula

Chart Prepared

by

FRED C. SCOBEY,

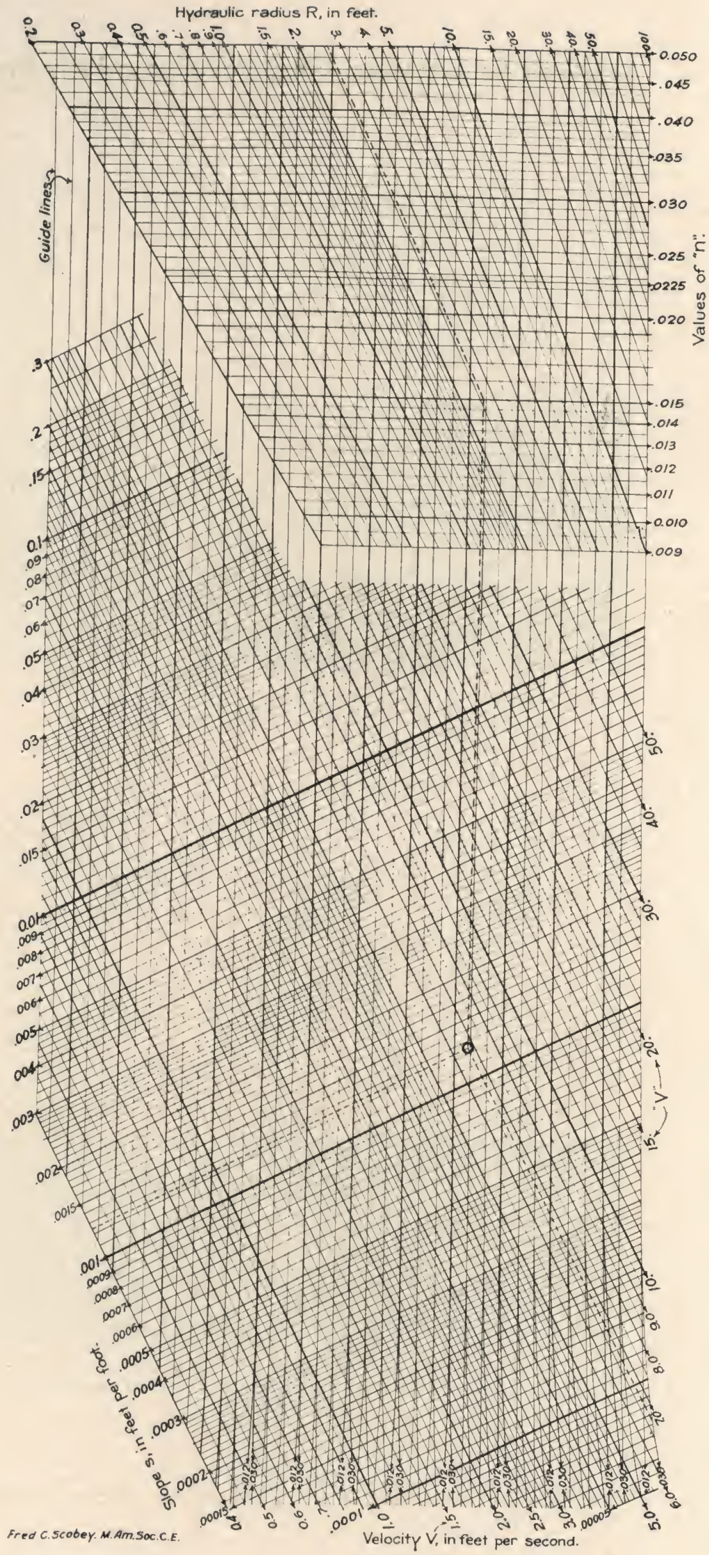
Member American Society of Civil Engineers,

Irrigation Engineer, U. S. Dept. Agriculture

for

Hydro-Electric Handbook

Creager & Justin



Battery of 48-inch Calco Automatic Drainage Gates Installed under the Old River Levee, near Little Rock, Arkansas.

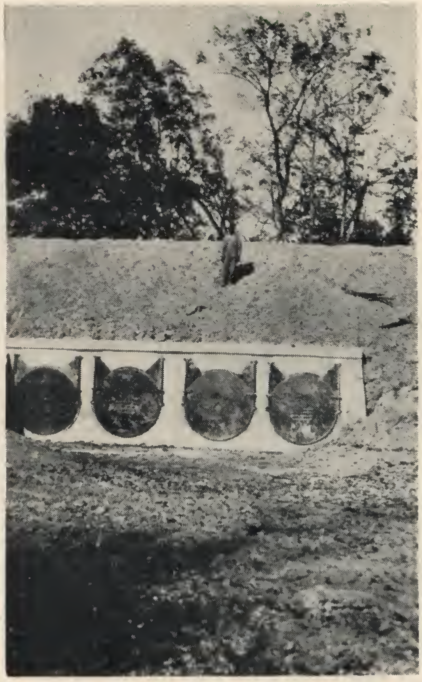
Five 72-inch Calco Automatic Drainage Gates, each attached to 80 feet of 10-gauge Armco Corrugated Pipe, for drainage and flood protection, near Sugarland, Texas.

A Calco Automatic Gate permitting maximum outflow. Note that the shutter is forced entirely away from the seat, thus causing practically no obstruction to the flow.

Armco Culvert and Calco Automatic Gate installation by Mr. P. F. Eller at Lanier Place on Shepard's Drive, Houston, Texas. The main culvert carries water in the drainage ditch which parallels the drive. The gate is used to permit water to drain off the low paved street where it intersects Shepard's Drive at considerable difference in elevation. When water in the drainage ditch is high the gate prevents backflow into the street. The high water marks on the concrete headwall indicate that the gate is faithfully serving its purpose.

Practical Canal Velocities

In earth canals erosion will occur if velocity is too great. At the same time low velocities should be avoided as such will permit the growth of aquatic plants, and if the water is silt laden, the deposit of silt. Hence, excessive velocity may occasion excessive wear of canal bed, while a sluggish flow will necessitate frequent canal cleanings. The accompanying tables, taken from "Irrigation Practice and Engineering" by Etcheverry, are guides to practical velocities which will minimize these difficulties.



Battery of Four 60-inch Armco Corrugated Pipes with Calco Automatic Gates installed in the White River levee, near Clarendon, Arkansas. The levee carries the main line tracks of the Missouri Pacific Railroad.

Maximum Mean Velocities Safe Against Erosion

Nature of Canal Bed	Mean Velocity in Feet per Second
Very light pure sand of quick-sand character	0.75— 1.00
Very light loose sand	1.00— 1.50
Coarse sand or light sandy soil	1.50— 2.00
Average sandy soil	2.00— 2.50
Sandy Loam	2.50— 2.75
Average loam, alluvial soil, volcanic ash	2.75— 3.00
Firm loam, clay loam	3.00— 3.75
Stiff clay soil, ordinary gravel soil	4.00— 5.00
Coarse gravel, cobbles, shingles	5.00— 6.00
Conglomerates, cemented gravel, soft slate, tough hard-pan soft sedimentary rock	6.00— 8.00
Hard rock	10.00—15.00
Concrete	15.00—20.00

Canal Velocities

Critical Velocities, or Mean Velocity, at which a Canal will neither silt nor scour are given in the following tables which were taken from "Working Data for Irrigation Engineers" by Moritz.

TABLE A

For Silt-Laden Waters

D Depth of Channel in Feet	Fine Light Sandy Silt	Somewhat Coarser Light Sandy Silt	Sandy Loamy Silt	Rather Coarse Silt or Debris of Hard Soils
	m = 0.84	m = 0.92	m = 1.01	m = 1.09
2.	1.30	1.43	1.56	1.69
2.5	1.51	1.66	1.81	1.96
3.	1.70	1.87	2.04	2.21
3.5	1.88	2.07	2.26	2.44
4.	2.04	2.24	2.45	2.65
4.5	2.20	2.42	2.64	2.86
5.	2.35	2.59	2.82	3.05
5.5	2.50	2.75	3.00	3.25
6.	2.64	2.90	3.17	3.43
7.	2.92	3.21	3.50	3.80
8.	3.18	3.50	3.82	4.13
9.	3.43	3.77	4.12	4.46
10.	3.67	4.04	4.40	4.77
11.	3.90	4.29	4.68	5.07
12.	4.12	4.53	4.94	5.36

TABLE B

For Canals Carrying Fairly Clear Water

D Depth of Channel in Feet	Fine Light Sandy Silt	Somewhat Coarser Light Sandy Silt	Sandy Loamy Silt	Rather Coarse Silt or Debris of Hard Soils
	m = 0.84	m = 0.92	m = 1.01	m = 1.09
2.	1.18	1.30	1.42	1.54
2.5	1.33	1.46	1.60	1.73
3.	1.45	1.59	1.75	1.89
3.5	1.57	1.72	1.89	2.04
4.	1.68	1.84	2.02	2.18
4.5	1.78	1.95	2.14	2.31
5.	1.88	2.06	2.26	2.44
5.5	1.97	2.16	2.37	2.56
6.	2.06	2.26	2.47	2.67
7.	2.22	2.44	2.68	2.89
8.	2.38	2.60	2.86	3.08
9.	2.52	2.76	3.03	3.27
10.	2.66	2.91	3.20	3.45
11.	2.79	3.05	3.35	3.62
12.	2.91	3.19	3.50	3.78

Table "A" is based on Kennedy's Formula $Vs=mD^{0.64}$, table "B" on $Vs=mD^{0.5}$.

Costs of Silt Removal in Canal Maintenance Taken from "Operation and Maintenance of Irrigation Systems" by S. T. Harding.

Table of Costs for Cleaning Small Canals

COST OF CANAL V-ING—IMPERIAL WATER CO. No. 1

Year	1912	1913	1914	1915
Number of Miles of Ditch V-d	481	431	448	361
Cost per mile for V-ing	$17.05	$21.99	$22.64	$28.02
Cost per mile for Repairs to Engine	13.43	14.31	16.29	16.40
Cost per mile for Repairs to V's	3.93	2.38	0.93	7.13
Cost per mile fuel and oil	6.52	6.69	6.64	8.05
Cost per mile of Mexican Labor following V.	13.42	16.04	21.07	21.64
Total Average cost per mile	$54.35	$61.41	$67.57	$81.24

The above costs are for cleaning small canals. In 1915 larger V's drawn by 4 caterpillar engines replaced small V's drawn by 2 engines. More than one cleaning per year was required.

Authorities agree that aquatic growth cannot form if velocity equals or exceeds 2.75 feet per second. In earth canals fouling by such growth may cause serious difficulties. In "Operation and Maintenance of Irrigation Systems" by S. T. Harding, it is stated that pondweed or moss—a common form of aquatic plant—may grow as much as 4 to 6 inches in length per day, and may reduce the normal canal capacity by over 50%.

Installation at Bay City, Texas, of Four Armco Corrugated Pipes 42 Inches in Diameter, Fitted with Automatic Gates, for the Drainage of Low-lying Lands into the Colorado River.

Three 30-inch Calco Automatic Gates Installed for Marsh Reclamation and Mosquito Control.

Side Slopes of Earth Canals

In the table are given side slopes customary in irrigation canals, but these may be modified by the topography of the land traversed by the canal and by the method of excavation.

If the topography requires a canal constructed in cut and fill, the canal banks in fill will be flatter than those in cut. If excavation is done with Fresno scraper slopes cannot be steeper than 1½ to 1 or even 2 to 1.

Table from "Irrigation Practice and Engineering—Conveyance of Water" by Etcheverry.

Material in which Cut is made	Side Slopes
Firm Rock	¼ to 1
Fissured rock, more or less disintegrated rock, tough hard-pan	½ to 1
Cemented gravel, stiff clay soils, ordinary hard-pan	¾ to 1
Firm, gravelly, clay soil, or sidehill cross-sections in average loam	1 to 1
Average loam or gravelly loam	1½ to 1
Loose, sandy loam	2 to 1
Very sandy soil	3 to 1

Trucking Some of the Big Gates and Pipes to the Marshes.

Pump Capacities

Normal pump capacities are closely related to the general matter of conveyance of water in open conduits, since many irrigators know the amount of water to be conveyed only in terms of pump sizes. By consulting this table and those on earlier pages showing rates of flow, it is quite practicable to determine the size of conduit required.

HORIZONTAL SINGLE RUNNER CENTRIFUGAL PUMP CAPACITIES

Number of Pump and Size of Suction and Discharge Openings in Inches	Gallons Per Minute	Cubic Feet Per Second	Net Water Horsepower Per Foot of Lift	Usual Pump Efficiency	Actual Horsepower Recommended Per Foot of Lift
1	20	.04	.006	30.0	.02
1½	50	.11	.013	32.5	.04
2	100	.22	.025	41.7	.06
2½	150	.33	.038	44.7	.085
3	225	.50	.057	50.0	.114
3½	300	.67	.08	50.0	.16
4	400	.89	.10	50.0	.20
5	700	1.56	.17	50.0	.34
6	900	2.01	.23	59.0	.39
7	1200	2.68	.31	62.0	.50
8	1600	3.57	.41	61.2	.67
10	3000	6.68	.76	65.0	1.17
12	4500	10.03	1.13	64.6	1.75

Necessary Capacity of Pumps in U. S. Gallons per Minute to give a 6-inch Depth of Water on the Land Each Month when Operated the Following Number of 24-Hour Days Each Month.

Taken from "Irrigation Practice and Engineering—Use of Irrigation Water" by Etcheverry.

Area Acres	30 Days	20 Days	15 Days	10 Days	5 Days	2.5 Days	1 Day
5	19	28	38	56	113	225	563
10	37	56	75	112	225	450	1125
15	57	85	113	170	340	675	1690
20	75	113	150	225	450	900	2250
30	113	169	225	338	675	1350	3375
40	150	225	300	450	900	1800	4500
60	226	338	450	675	1350	2700	6750
80	300	450	600	900	1800	3600	9000
120	450	675	900	1350	2700	5400	13500

CONVERSION TABLE—Rates of Flow

Equivalent values are shown in the same horizontal line

Cubic Feet Per Second	(1) Miner's Inches	(2) Miner's Inches	U. S. Gallons Per Minute	Acre-Feet Per 24-Hours	Acre-Feet Per Year (365)	Million U. S. Gallons Per 24 Hours	Inches Depth Per Acre in 24 Hours
I	50	40	448.83	1.9835	723.97	0.646,317	23.802
0.0200	I	0.80	8.98	0.0397	14.48	0.012,926	0.476
0.0250	1.25	I	11.22	0.0496	18.10	0.016,158	0.595
0.002,23	0.1114	0.0891	I	0.00442	1.61	0.001,440	0.053
0.504	25.21	20.17	226.29	I	365.	0.325,851	12.
0.001,38	0.069	0.055	0.62	0.00274	I	0.000,892	0.033
1.547	77.36	61.89	694.44	3.07	1120.14	I	36.84
0.0420	2.10	1.68	18.86	0.083	30.3	0.027,15	I

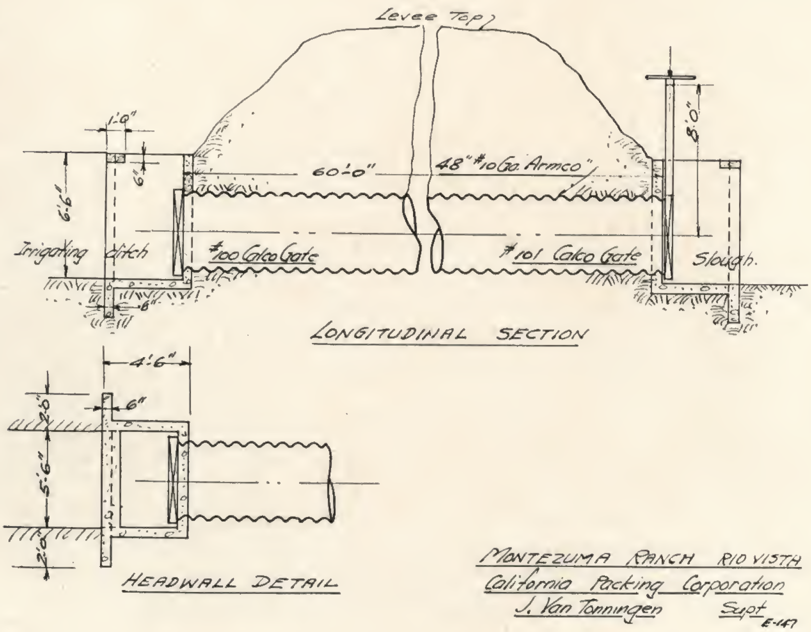
(1.) 50 Miner's Inches = 1 cubic foot per second. (Southern California, Idaho, Arizona, Nebraska, New Mexico, Oregon, Utah, Washington.)

(2.) 40 Miner's Inches = 1 cubic foot per second. (California statute, Montana, Nevada.)
38.4 Miner's Inches = 1 cubic foot per second. (Colorado.)

QUANTITY UNITS

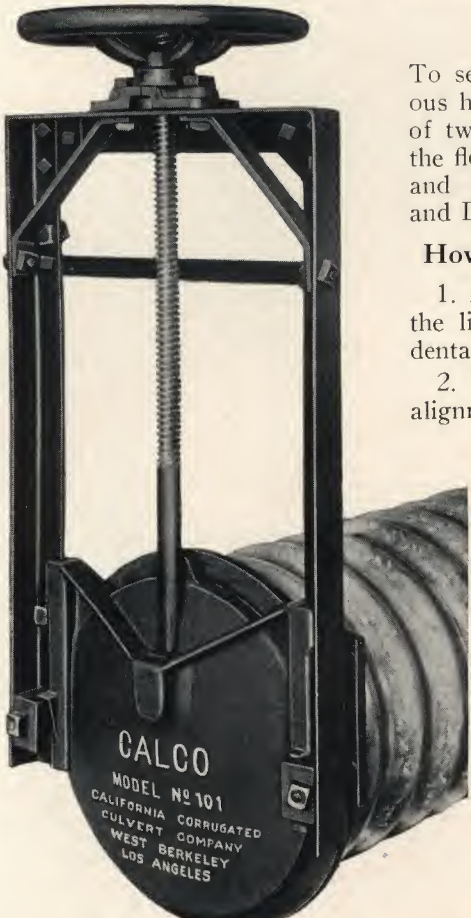
1 cubic foot = 7.48 U. S. gallons.
1 acre foot = 43,560 cubic feet. (325,851 U. S. gallons.)

Calco Automatic Drainage Gate on a Typical California Reclamation District. Backflow from the Slough at High Tide is Effectively Prevented.



Typical Gate and Pipe Design for Marsh Drainage, Showing Use of Calco Automatic and Slide Gates with Armco Corrugated Pipe.

The Calco Slide Headgate



Model No. 101

To serve as an inlet gate under various heads of water up to a maximum of twenty feet. Useful in controlling the flow from reservoirs, rivers, canals and ditches. Practical, Watertight, and Durable.

How It Is Constructed and Why

1. All parts are of cast iron except the lifting rod and frame, with incidental bolts and nuts.

2. The slide is guided by angles in alignment with seat, and surfaces of each are ground smooth.

3. Double-cut acme threads on the stem permits of rapid operation of the slide. When closed, the slide wedges tightly against the seating ring, *insuring practical water-tightness.*

4. The seating ring for slide and frame is securely attached to desired lengths of Armco Corrugated Pipe. Structures of a moderate size may be shipped complete, ready for installation.

Armco Corrugated Pipe, while the strongest of cylinders in proportion to the material employed, is of comparatively light weight, and can be easily transported and handled. Its corrugations impart, not only great strength, but a certain flexibility as well which enables it to conform to such yielding or unstable foundations as may be encountered in wet earthen banks.

Calco Slide Headgates are often employed on the inlet ends of corrugated pipes which have Calco Automatic Gates on their outlet ends, as shown in the drawings on earlier pages. This arrangement makes it easily possible to retain drainage water on marsh lands when desired for silt upbuilding or for pond maintenance and at other times to permit free outflow, while wholly preventing re-flooding from the river or bay.

Calco Slide Headgates are made in diameters ranging from 8 to 72 inches.

WHAT USERS SAY *of the* Calco Slide Headgate:

Sacramento, Calif., Jan. 11, 1926.

We have found your Calco Slide Headgate and attached thereto Armco corrugated pipe to be a very suitable installation in the Delta Sections of the Sacramento and San Joaquin Rivers.

What appeals to us is the ease of installation. I have records of installations made in 1915 and find the pipe and gates in good condition.

In many instances in some of the Reclamation Projects we find it advisable to remove a pipe and gate to another location. If care is taken these pipes and gates can be taken out and set in other locations without damage to the equipment.

F. H. REYNOLDS & CO.,
By F. H. REYNOLDS.

Santa Maria, Texas, June 11, 1923.

For several years we have been using Calco Slide Headgates, Model 101, and the gates first installed are in perfect condition today. We have found this gate the simplest and most satisfactory gate we have ever used.

SANTA MARIA WATER IMPROVEMENT DIST., CAMERON COUNTY NO. 4,
By J. R. HOPKINS, *Manager.*

San Francisco, Calif., Dec. 31, 1925.

The Calco Slide Headgates and pipes installed over 12 years ago are in good order and giving perfect satisfaction.

WESTERN LAND AND RECLAMATION COMPANY,
By F. D. MONCKTON, *Secretary.*

San Francisco, Calif., Jan. 9, 1926.

The writer found during the past year that the Calco gates and culverts installed on my ranch near Corcoran, Tulare County, California, are in splendid condition and serving my irrigation system in very good shape.

HOWARD H. BRU.

Sacramento, Calif., Jan. 11, 1926.

I am using a number of your Calco Slide Headgates and Armco corrugated pipes. The headgates give perfect service under all conditions, and the Armco pipe shows absolutely no sign of rust or decay. I am very well satisfied with your products.

G. W. SCRIBNER.

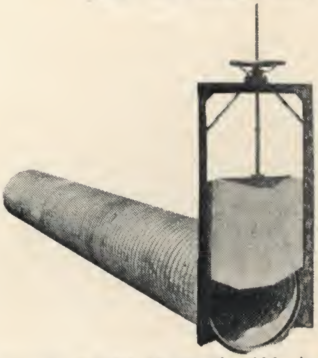
McAllen, Texas, Oct. 7, 1925.

We have been buying the Calco Slide Headgate, Model 101, for the past four years. It has given entire satisfaction and has proven to be practically a water-tight valve. For this reason we keep installing them. They save water and reduce our seepage troubles.

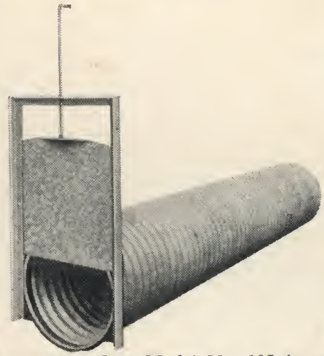
HIDALGO COUNTY WATER IMPROVEMENT DISTRICT NO. 3,
By ROBERT HENDERSON, *Manager.*

Other Practical and Popular Calco Gates

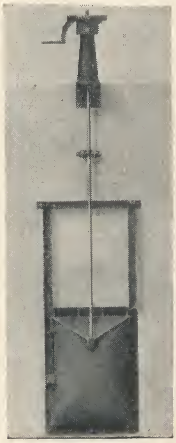
Made from Pure and Rust-Resisting "Armco" Ingot Iron and Cast Iron



Calco Lateral Gate Model No. 106. A convenient and practical headgate for farm laterals. The hand-wheel lift adds greatly to ease of operation.

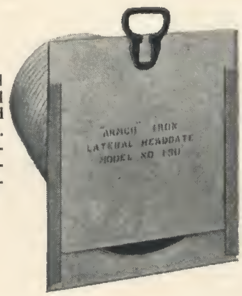


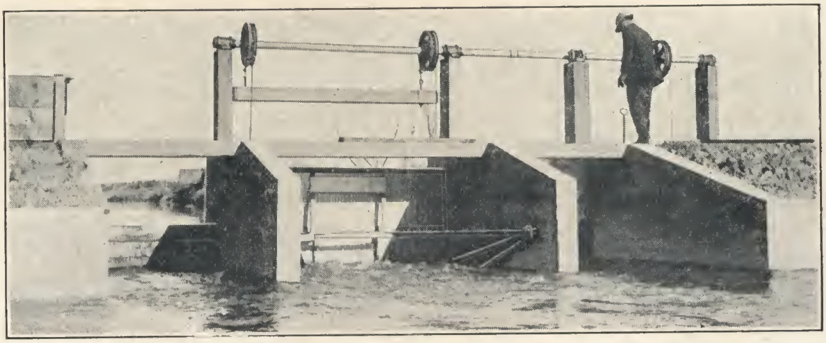
Calco Lateral Gate Model No. 105 for moderate water pressures. The cast iron seat and structural frame give rigidity and strength.



Calco Rectangular Gates Model 173 with pedestal or hand wheel lifts used as controls for penstocks, waste gates for dams, as head sluice or distributing gates for irrigation and reclamation systems.

Armco Lateral Gate Model No. 150. Hand or screw lifts. For use in laterals. A low-cost but effective gate for irrigation.





Calco Automatic Radial Headgate Model, No. 120, for keeping water in supply canals at CONSTANT LEVELS, preventing washouts and the ravages of rodents in the banks, making possible the accurate measurement of water to users and reducing the labor of supervision.

ARMCO

CALIFORNIA CORRUGATED CULVERT CO.

LOS ANGELES WEST BERKELEY

CALIFORNIA CORRUGATED CULVERT CO.

LOS ANGELES WEST BERKELEY